WATER TREATMENT PROGRAM
TRAINING MANUAL

HEATING AND COOLING SYSTEMS

PUBLIC WORKS, SUPPLY AND SERVICES
Property Management Division

CANADIANA
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WATER TREATMENT PROGRAM
TRAINING MANUAL

HEATING AND COOLING SYSTEMS

PREPARED
BY

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INTRODUCTION & ACKNOWLEDGEMENT

INTRODUCTION:

The Operating Personnel involved in the Water Treatment Program come from various trade backgrounds and they may not have received any formal training in Water Treatment.

In order to maximize their operational skills so that they fully understand the value and significance of the systems and the Water Treatment Programs, it has become necessary to introduce this "Water Treatment Training Manual".

It is the intent of this manual to provide training in basic water chemistry, water testing, and water treatment applications. A section on systems and classifications is included showing their recommended operating guidelines.

A glossary of water chemistry terms is included for reference purposes.

ACKNOWLEDGEMENTS:

I wish to thank the Water Treatment Consulting Committee members and H_2O Engineering for their valuable input and review in the preparation of this manual.

I would also like to thank the Director, Water Treatment Program and the Manager, Inspection and Specialty Services for helping me to decide the best delivery technique of this training manual.

WATER TREATMENT PROGRAM

TRAINING MANUAL

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SECTION I

COURSE AGENDA

AGENDA

Topic:	Water Treatment Training Course - Heating and Cooling Systems
Objective:	To provide basic knowledge of water chemistry, testing and water treatment applications.
Scope:	Limited to the Water Treatment Program's recommendations for treatment of heating and cooling systems.
Participants:	Water Treatment Co-ordinators and Building Operators
Location:	Centrally in each Water Treatment Co-ordinator's area
Instructor:	Sam Seepersad Chemical Technician Water Treatment Program

Course contents and time table are as follows:

Times	Activities
08:30 - 08:35	Introduction, welcome and opening remarks - Water Treatment Co-ordinator for the specific area
08:35 - 08:40	Philisophy of the Property Management Division's Water Treatment Program
08:40 - 08:45	Course overview: Contents, materials and methods of instruction
08:45 - 09:00	Lecture: - Heating/cooling systems classifications and types - Systems mechanical tune-up, care and operation - Aims and objectives of Industrial Water Conditioning

Agenda

Times	Activities
09:00 - 09:15	Film: "Working with Water" - deals with the basic chemistry of water and its characteristics - shows Industrial Water Conditioning and their applications - shows the utilization of the principles of water chemistry to carry out treatment responsibilities more effectively to ensure efficient plant operation
09:15 - 09:30	Discussion on film "Working with Water" and the notes summary
09:30 - 10:00	Questionnaire: - 5 basic questions on the subject "Working with Water" - Review of answers to questions
10:00 - 10:15	COFFEE BREAK
10:15 - 10:30	Film: "Water Testing" - outline guides for collecting samples, sources and precautions - states general chemical test procedures, equipment and reagents required - shows documentation of chemical test results and their applications
10:30 - 10:45	Lecture: - sampling containers, method and source of sampling, precautions when taking a sample. - testing equipment, reagents and shelf life - testing procedures, test results and record keeping - interpretations and application of test results - field testing schedule - chemical control ranges of heating/cooling systems - water treatment chemicals, handling and precautions, safe storage of chemicals and shelf life - chemical feed systems, types and methods of operations - chemical addition, methods and precautions.

Agenda

Times	Activities
10:45 - 11:00	5 basic questions on water testing. Review of answers to questions
11:00 - 12:00	"Hands on Water Testing" - participants will be asked to run at least two chemical tests on the portable laboratory. These tests will be applicable to the water system under their charge.
12:00 - 13:00	LUNCH BREAK
13:00 - 13:15	Film: "Scale Control Begins Here" - shows the plant operator's role in interpreting water test results in a Preventative Maintenance Program - shows how the water test results can be used to control deposits and condition sludge
13:15 - 13:30	Lecture: - scale constituents, factors in formation - prevention and control of scale formation and removal - sludge constituents, conditioning and removal by blowdown
13:30 - 14:00	Questionnaire: - 5 basic questions on scale control - review of answers to questions
14:00 - 14:15	COFFEE BREAK
14:15 - 14:30	Film: "Corrosion Control in Boiler Operation" - shows how metal loss in boilers, feedwater and condensate systems contribute to internal boiler deposits, tube failures and reduce efficiency - shows the operator's role in the control of corrosion by checking systems operations and by having a good water treatment program
14:30 - 14:40	Lecture: - corrosion, types and causes - corrosion, monitoring - corrosion control, inhibitors

Agenda

Times	Activities
14:40 - 15:00	Questionnaire: - 5 basic questions on corrosion control - review of answers to questions
15:00 - 15:10	Facilities, supplies & services available - role of Central Laboratory - supply of chemical test reagents and testing equipment - analytical services - monitoring sample schedule - materials available, sample bottles, cartons, etc. - water treatment manuals
15:10 - 15:15	Role of the Water Treatment Co-ordinator: - field visits and system checks - testing equipment and chemical test reagents
15:15 - 15:20	Role of the Water Treatment Consultant: - technical support - system inspection and water treatment recommendations.
15:20 - 15:25	Issuance of Certificates to participants
15:25 - 15:30	Completion of feedback information form
15:30	Closing remarks.

NOTES

SECTION II

SYSTEMS CLASSIFICATIONS

CARE & OPERATION

CLOSED HOT WATER SYSTEM

Description:

A closed hot water system, a typical drawing of which is indicated in fig. 1 overleaf, is a heating system where hot water is circulated throughout the building or through heating coils in an H.V.A.C. system to provide space heating.

The heat source may be converters, fired heaters or fired boilers.

The principle components of these systems consist of a heat source, automatic air vent, circulating pump, expansion tank, heat exchangers, chemical pot feeder (not shown) and metered water make-up.

Operation & Maintenance

- limit make-up
- positive pressure
- level in expansion tank
- auto vents closed

Chemical Treatment:

Sulphite	50 - 100 ppm.
PH	8.5 - 9.5

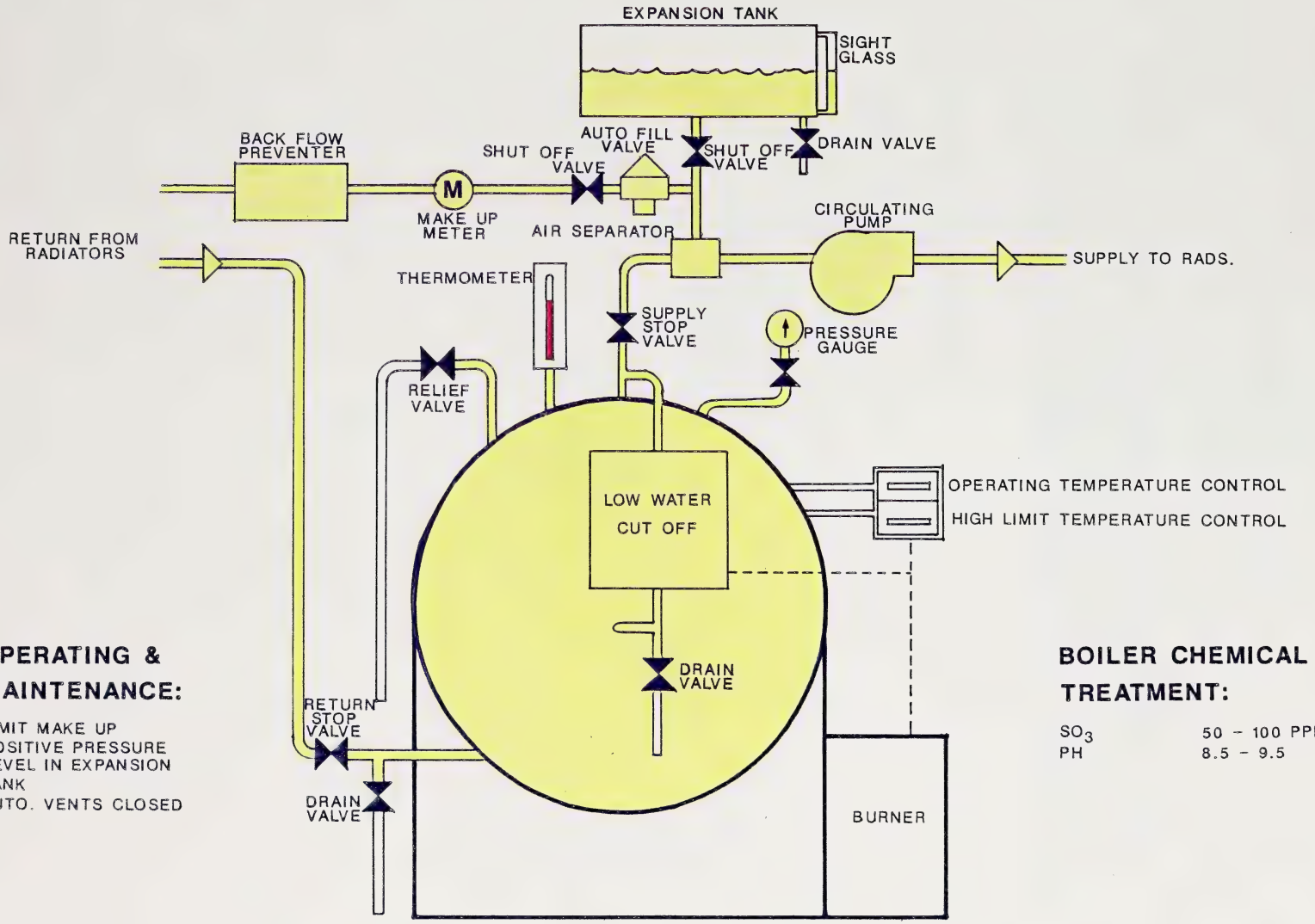
Testing Frequency:

At least once per month or more frequently if test results fluctuate.

Log the make-up water meter reading at least once per month.

HOT WATER BOILER

FIGURE 1.



OPERATING & MAINTENANCE:

LIMIT MAKE UP
POSITIVE PRESSURE
LEVEL IN EXPANSION
TANK
AUTO. VENTS CLOSED

BOILER CHEMICAL TREATMENT:

SO_3	50 – 100 PPM
PH	8.5 – 9.5

STEAM BOILER SYSTEM - CLOSED

Description:

A closed steam boiler system, a typical drawing of which is shown in Fig. 2 overleaf, is a system which provides steam for space heating.

A basic system consists of the boiler heating coils, condensate return system, boiler feedpump, chemical feeder (not shown) and make-up water meter.

Operation & Maintenance:

- limit make-up
- blow down gauge glass
- prove bottom blowdown
- inspect once a year
- store empty

Chemical Treatment:

Boiler Water

TDS	1500 - 3000
Phosphate	40 - 80 ppm. PO4
'OH' alkilinity	150 - 300 ppm
Sulphite	30 - 60 ppm SO_3
PH	10.5 - 11.5

Condensate:

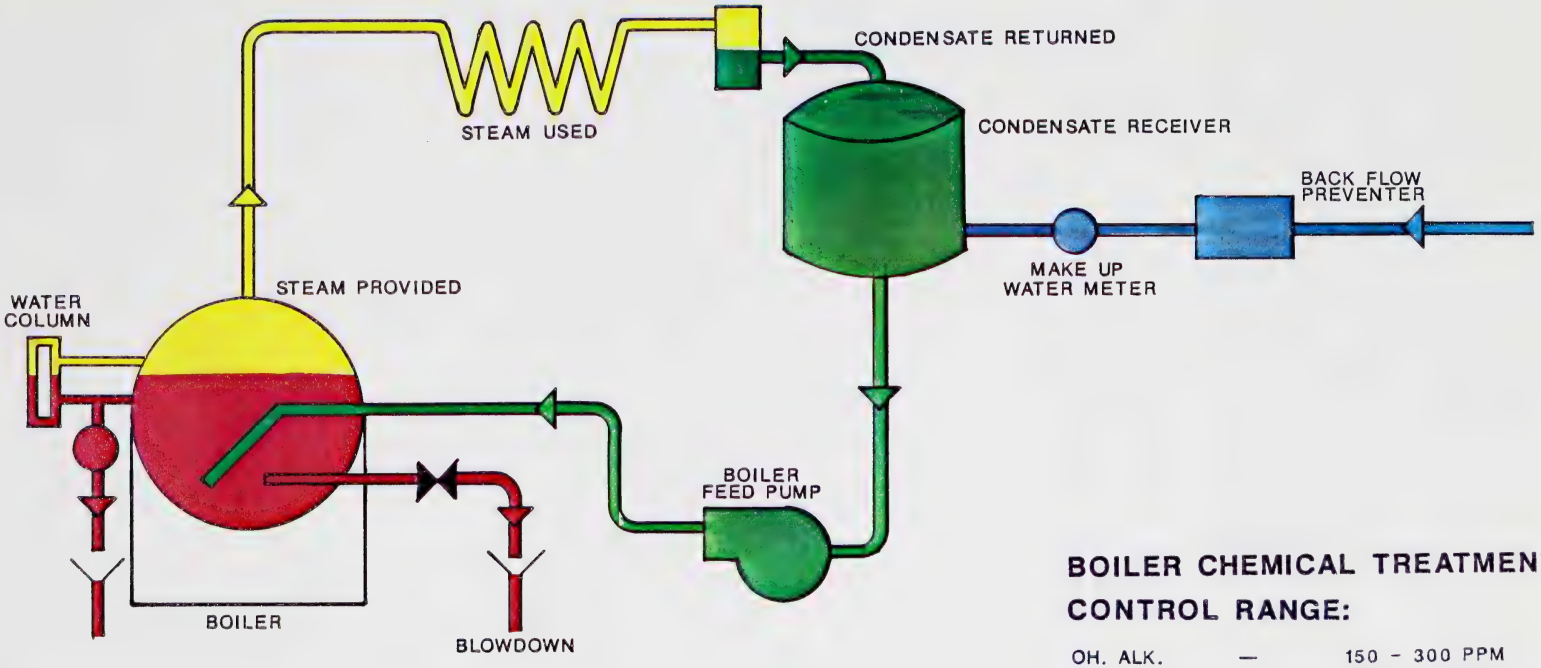
PH	8.5 - 9.5

Testing Frequency:

1 - 2 days

Figure 2

STEAM BOILER SYSTEM – CLOSED



BOILER CHEMICAL TREATMENT CONTROL RANGE:

OH. ALK.	—	150 - 300 PPM
TDS	—	1500 - 3000 PPM
SO_3	—	30 - 60 PPM
PO_4	—	40 - 80 PPM
PH	—	10.5 - 11.5

STEAM BOILER SYSTEM - OPEN

Description:

An open steam boiler system, a drawing of which is shown in Fig. 3 overleaf, is a system which provides steam for one or more of the following uses: space heat, humidification, indirect contact cooking and sterilizing or power generation. At some point along the steam travel, the system is open to the atmosphere.

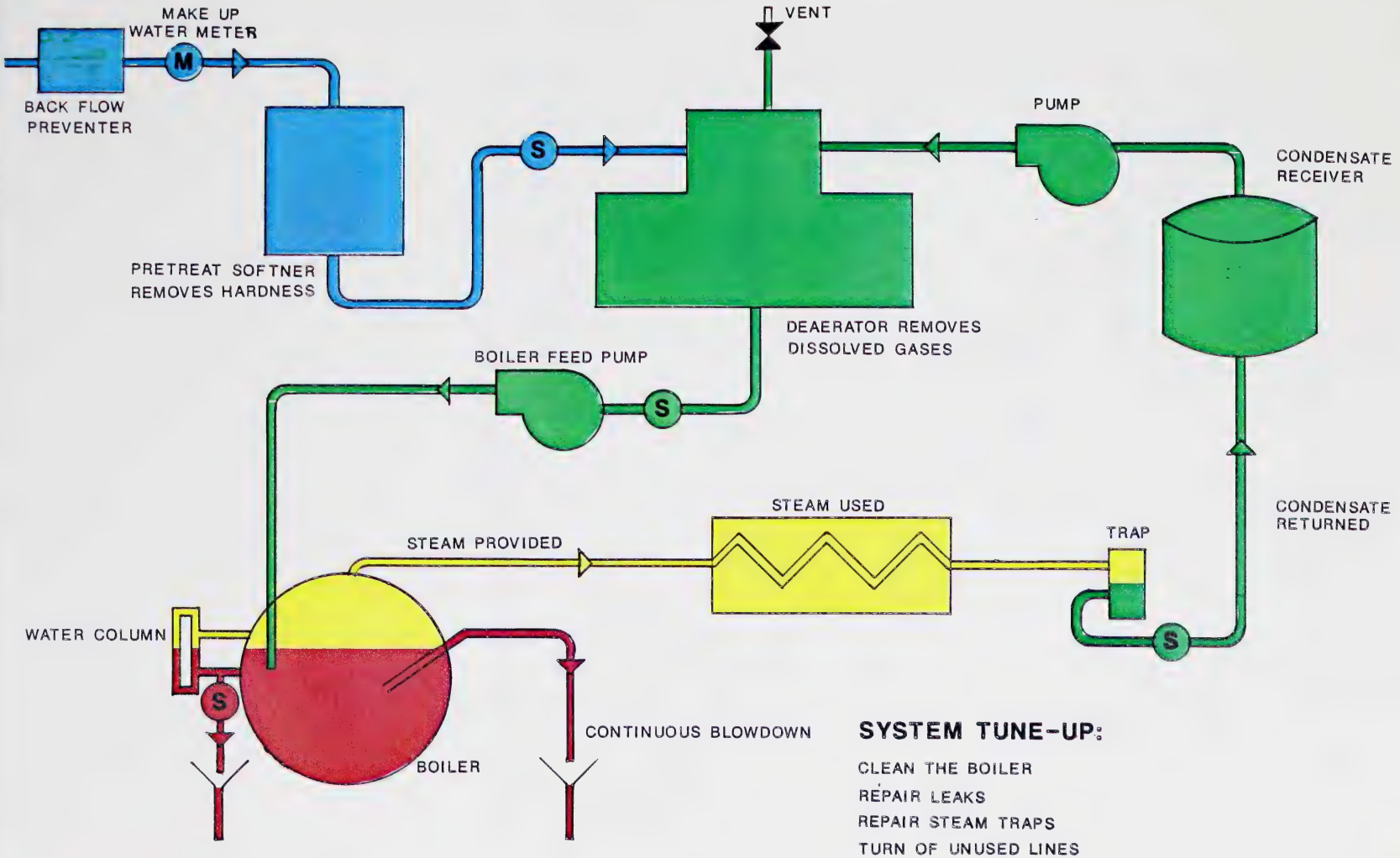
A basic system consists of the boiler. Depending on the size of the system and the end use of the steam, other components may include a converter or heating coils, condensate receiver, condensate pump, deaerator, feed pump, boiler feed pump, or power generating equipment and make-up water treatment equipment.

System Tune-up:

- cleaner boiler
- repair leaks
- repair steam traps
- turn off unused lines
- replace lost insulation

Figure 3.

STEAM BOILER SYSTEM – OPEN



SYSTEM TUNE-UP:

CLEAN THE BOILER
REPAIR LEAKS
REPAIR STEAM TRAPS
TURN OF UNUSED LINES
REPLACE LOST INSULATION

S – SAMPLING POINT

Operation & Maintenance: (Refer Fig. 4 overleaf, pg. 12)

- limit make-up
- blow down gauge glass
- prove bottom blow down
- inspect once a year
- store empty

Chemical Treatment & Tests

Boiler Water:

OH alkalinity	150 - 300 ppm
T.D.S.	1500 - 3000 ppm
SO_3	30 - 60 ppm
PO_4	40 - 80 ppm
PH	10.5 - 11.5

Boiler Feed:

Total Hardness (2.0 Max.)

Condensate:

PH (8.5 - 9.5)

Softened Water:

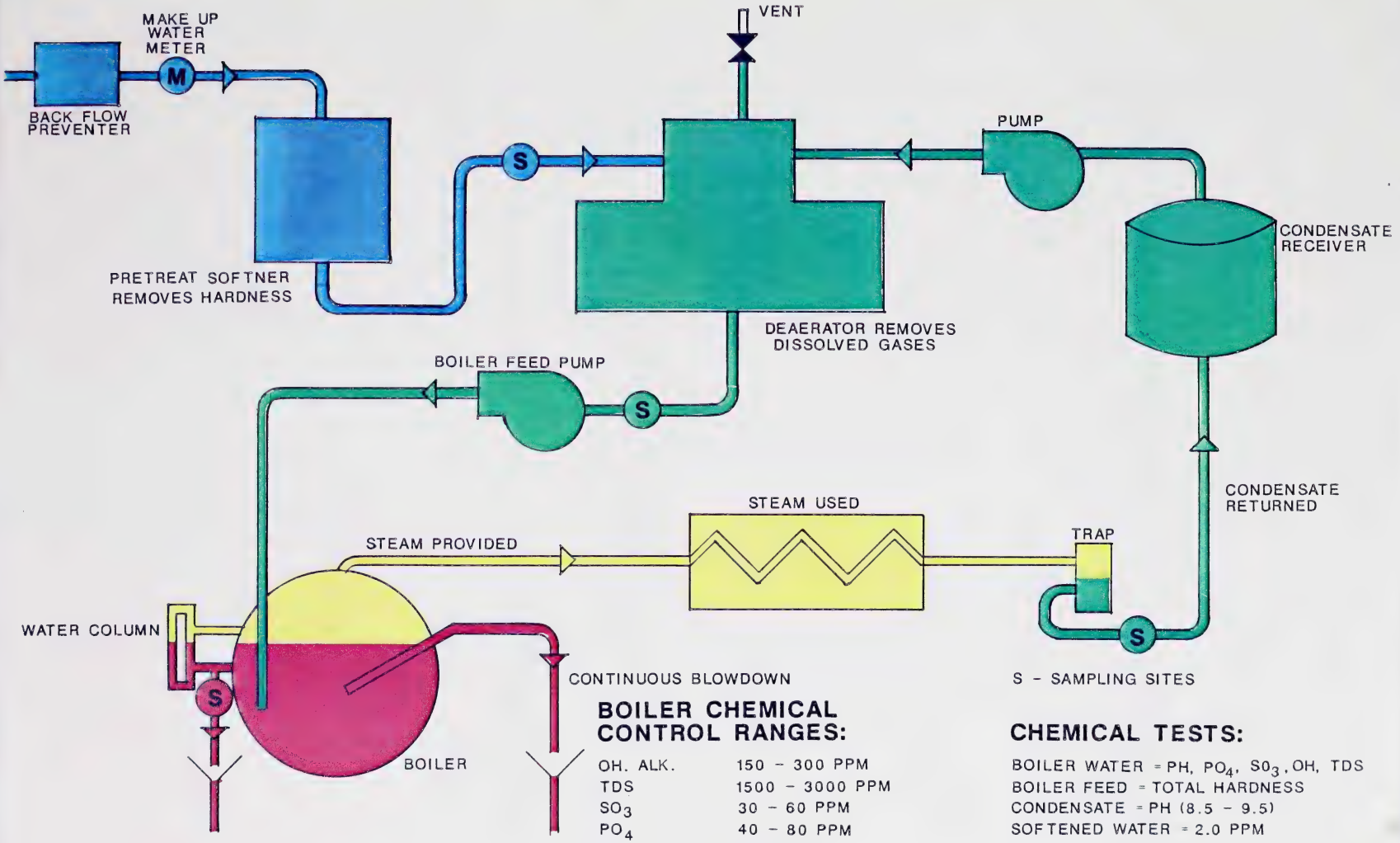
Total Hardness (2.0 Max.)

Testing Frequency:

1/day for power boilers
1/day for open heating boilers
1/week for humidification boilers
1/day for humidification boilers at the Provincial Museum & Archives
1/day for boiler feed water and condensate

Figure 4

STEAM BOILER SYSTEM – OPEN



BOILER CHEMICAL CONTROL RANGES:

OH. ALK.	150 – 300 PPM
TDS	1500 – 3000 PPM
SO_3	30 – 60 PPM
PO_4	40 – 80 PPM
PH	10.5 – 11.5

CHEMICAL TESTS:

BOILER WATER = PH, PO_4, SO_3, OH, TDS
BOILER FEED = TOTAL HARDNESS
CONDENSATE = PH (8.5 – 9.5)
SOFTENED WATER = 2.0 PPM

CHILLED WATER SYSTEM

Description:

A chilled water cooling system, a drawing of which is shown in Fig. 5 overleaf, is a cooling system where water is circulated throughout the building or through cooling coils in an H.V.A.C. system to provide space heating.

The cooling source may be a chiller of the absorption type or the compression type, or a cooling tower in chiller by-pass system.

The components of a basic cooling system consist merely of a cooling source, circulating pumps and cooling coils whereas a more complex system may contain an expansion tank, chemical pot feed, by-pass filter and metered water make-up.

Operation & Maintenance

- limit make-up
- positive pressure
- level in expansion tank

Chemical Treatment

sodium sulfite:	50 - 100 ppm
cobaltous chloride (catalyst)	20m/16 sulfite added
caustic to maintain PH	8.9 - 9.5

Testing Frequency:

At least once per month or more frequently if test results fluctuate between testing.

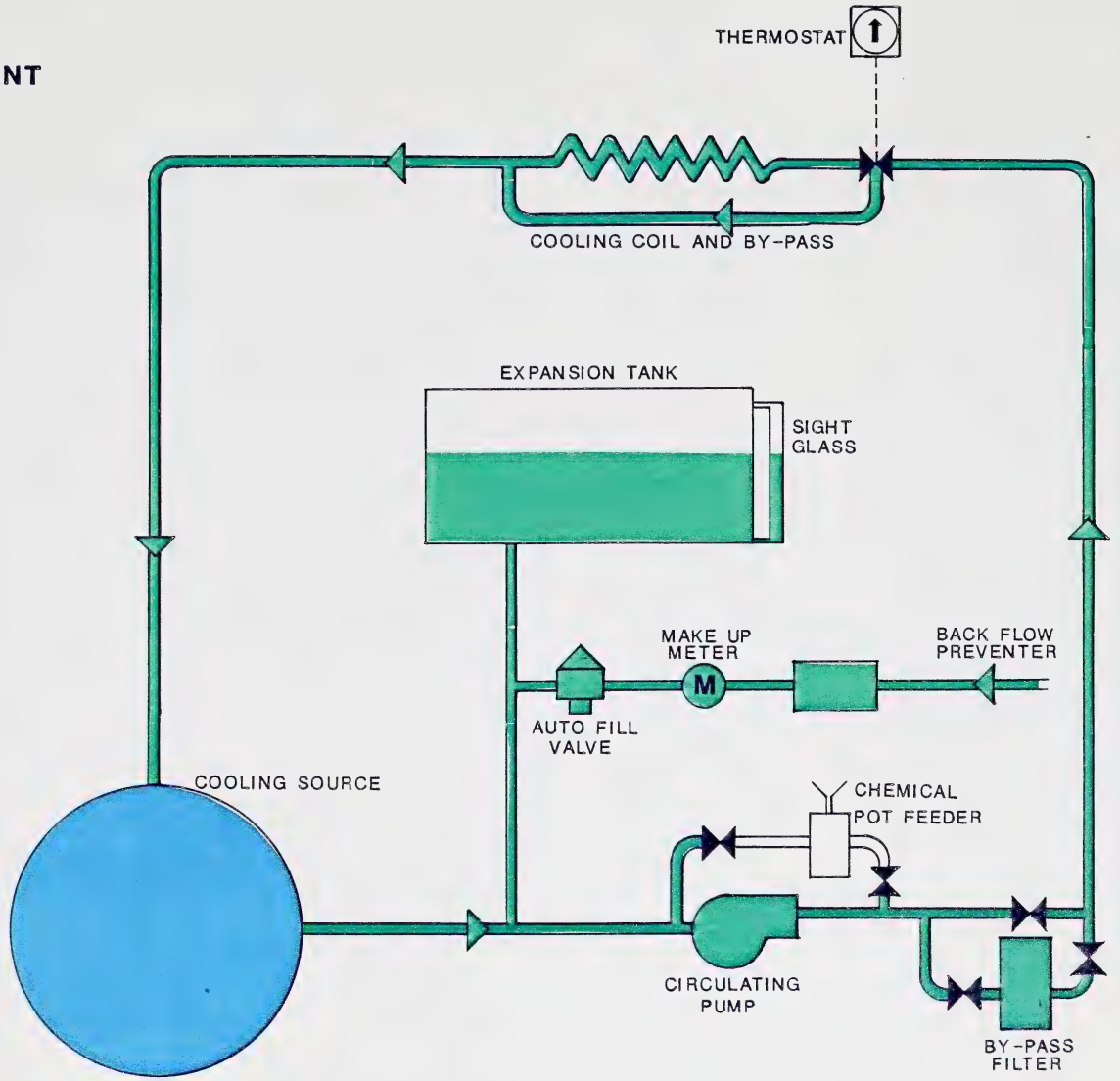
Log make-up water and T.D.S. at least once per month.

CHILLED WATER SYSTEM

Figure 5

CHEMICAL TREATMENT
CLOSED SYSTEM:

CATALYST	-	20 ml/lb SULFITE
PH	-	8.5 - 9.5
SO_3	-	50 - 100 PPM



NOTES

SECTION III

WORKING WITH WATER

WORKING WITH WATER

Notes:

1. The raw water supplies available for use in cooling systems and boilers are seldom useable as is. Managing water, tailoring it to suit the plant's particular requirements is necessary to keep water from causing scale, corrosion, and deposits.

2. The water we work with always contains impurities and dissolves anything and everything it contacts, to some extent.

3. Some of the problem impurities in water we have to deal with are calcium and magnesium salts. When they dissolve in water, they split into smaller units called ions and no longer exist as the original compounds. These substances are said to be ionized.

4. The greater the amount of ionizable substances dissolved in a solution, the more easily the solution will conduct electric current, therefore conductivity measurements determine the approximate concentration of ionized impurities in the water.

5. Free hydrogen ions in water are Acid ions; 'OH' ions in water are Alkaline ions. PH measurements determine the hydrogen ion concentration in water.

6. Alkalinity is measured by titration and the impurities that constitute alkalinity have a strong influence on corrosion and scaling. Alkalinity can decrease the solubility of troublesome impurities in water.

7. With most compounds, the higher the water temperature, the more soluble they become. A few compounds such as those which cause hard scale become less soluble in water as the temperatures go up.

8. Increasing water temperature speeds up the rate of deposit formation, corrosion and scaling.

9. When water evaporates or converts into steam, the impurities are left behind and concentrate in the remaining water. They remain in solution until the limit of solubility is reached. Any excess impurity over this limit will precipitate.

10. Hard scale forms direct from solution at the heat transfer surface and consist of impurities that get less soluble as the water temperature goes up. The impurities in the film of water right next to the heated surface are more concentrated than those in the bulk of the boiler water.

11. Insoluble deposits that do not form direct from solution at the heating surface include substances such as suspended solids, contamination, corrosion products and iron, and these deposits are generally softer and more porous than hard scale.

12. Deposit formations may be caused by sludge and suspended solids, airborne contaminants, bacteria, corrosion products and algae.

13. Where water flow velocity is low in cooling systems, suspended solids settle to form deposits. These deposits interfere with inhibitor performance, provide corrosion sites, impede heat transfer, and retard water flow.

14. Ways and means of controlling deposit formation in boiler and cooling towers include: chelants, blowdown, sludge conditioning, internal treatment for boilers and corrosion inhibitors, biocides, bleed off, dispersants, sequestrants and filtration for cooling systems.

15. Corrosion is the process of metal being dissolved, decomposed or eaten away by the impurites in the water. In boilers and condensate return systems, the corrosive impurities are mainly dissolved carbon dioxide and oxygen.

16. The rate of corrosion is influenced by the presence of deposits, concentration of impurities, system temperature, water flow rate and PH level.

17. 'PH' is a key factor in corrosion. If you raise PH, you retard corrosion.

18. Methods by which corrosion can be controlled in boiler and condensate systems include sulfite, deaeration and filming inhibitors against oxygen attack, and neutralizing inhibitors, filming inhibitors and reduce alkalinity of make-up water against acid attack.

19. Blowdown and bleed-off are needed in boilers and cooling systems to reduce concentration of corrosive impurities and also reduce the amount of suspended, insoluble impurities that are responsible for deposits.

20. When boiler water flashes into steam, insoluble impurities left behind precipitate in the form of boiler sludges and scale deposits and pre-treatment for boiler scale may include ion exchange methods and precipitation methods.

WORKING WITH WATER

1. Managing water, conditioning it to suit your plant's particular requirements is necessary to keep the water from causing:

   (a) scale
   (b) corrosion
   (c) deposits

   Circle every answer you think is correct.

2. Hard scale forms direct from solution at heat transfer surface and consists of impurities that get less soluble as the water temperature goes up.

   True or False?_____

3. Methods for scale prevention in boilers include:

   (a) internal treatment
   (b) sludge conditioning
   (c) blowdown

4.(a) When water containing dissolved oxygen contacts iron, the metal begins to corrode.

   True or False?_____

   (b) When carbon dioxide dissolves in water it forms carbonic acid.

   True or False?_____

5. Deposit formations may be caused by:

   (a) sludge and suspended solids
   (b) corrosion products
   (c) high dissolved solids

   Circle every answer you think is correct.

NOTES

SECTION IV

WATER TESTING & RECORD KEEPING

CHEMICAL CONTROL RANGES

CHEMICAL ADDITION

WATER TESTING

1. Water circulating in a boiler or cooling system must be constantly corrected to prevent problems and to insure proper operation: regular, accurate water testing is needed to control impurities, treatment levels, corrosion and deposits.

2. Various methods of water testing include titration, color comparison, electronic metering and indicator paper test.

3. To be valid, a water sample must be representative of all the water in that circuit at the time it is collected.

4. Use of a cooling coil at the sampling site will: prevent flashing, protect you from being scalded, eliminate concentration of the sample, provide a more accurate sample and save time and trouble.

5. When taking a sample: flush cooling coil thoroughly beforehand; if there is no cooling coil, flush the line thoroughly beforehand. Use a clean container and rinse container in water being sampled. Take a volume of water more than enough for all required tests.

6. When making a test be sure that all equipment is clean and in good order, test solutions, indicators and reagent are fresh and at full strength and before a measuring cylinder is used, it's rinsed with sample being tested. Old or weak test chemical will result in inaccurate test results, therefore it is a good policy to replace test solutions and reagents about every 12 months.

7. To do a typical titration, you will need the following: prepared sample, measuring cylinder, casserole, indicator, test solution, burette and stirring rod.

8. The titrating solution is put into the sample after the indicator is added and the end point of a titration is reached when one final drop of standard test solution produces the first permanent color change. The amount of titrating solution used to reach the end point is generally measured in millilitres or ml for short.

9. The term 'PPM' is short for parts per million, one unit in which concentration of impurity is reported.

10. In a measuring cylinder or burette the surface of the liquid is always curved. This curve is called a meniscus. When reading the level of the liquid, you always read the bottom of this curve.

11. To arrive at the concentration of an impurity in a sample being tested, you multiply the amount of test solution used by a standard factor or constant that you'll find in your test procedure or manual.

12. You normally run the Sulfite test as soon as possible after you collect the sample because sulfite reacts with oxygen in the air.

13. Color comparison testing involves comparing the colors developed in test samples with color standards of known concentration. Various color comparison tests for a given impurity may use different reagents and develop different colors in the comparators.

14. On a typical color comparison test, a special reagent develops a color in the sample in proportion to the concentration of the impurity. We compare the shade of the sample with the color standards of known concentrations to determine the concentration in the sample. Color comparison tests are commonly used for determining Ph in condensate, Iron in condensate, and Ph and phosphate in boiler water.

15. Please follow standard "Field Testing Schedule" Guide, ensure accurate and up-to-date recording of the results obtained. If in doubt, contact the Central Laboratory or our Water Treatment Consultant.

ABRIDGED WATER TEST PROCEDURES

[Note: Analyst should be familiar with the detailed procedures in the Water Treatment Program Manual]

OH Alkalinity (as ppm CaCO3)

-50 ml sample
-0.2 g OHB-202
-2-3 drops P Ind-602
-titrate OHT-201 to clear
-ml X 20

Sulfite (as ppm SO3)

-50 ml sample
-1 ml SB-302
-0.2 g S Ind-303
-titrate ST-301 to blue
-ml X 10

Total Hardness, High, >10 ppm (as ppm CaCO3)

-50 ml sample
-0.5 ml HB-402
-0.2 g H Ind-403
-titrate HT-401 to blue
-ml X 20

Total Hardness, Low, <10 ppm (as ppm CaCO3)

-100 ml sample
-1 ml HB-402
-0.05 g H Ind-403
-titrate LHT-501 to blue
-ml X 1

pH (as pH units)

-5 ml sample
-to tube in centre hole of comparator
-0.5 ml indicator to centre tube
-5 ml sample to outside tubes
-match colour on slide
-slide reading X 1

P & M Alkalinities (as ppm CaCO3)

-50 ml sample
-2-3 drops P Ind-602
-titrate OHT-201 to clear
-P = ml X 20
-2-3 drops M Ind-703
-continue titration OHT-201 to orange
-M = total ml X 20

Chloride (as ppm Cl)

-50 ml sample
-1 ml C Ind-703
-titrate CT-701 to pinkish yellow
-ml X 10

TDS (as ppm)

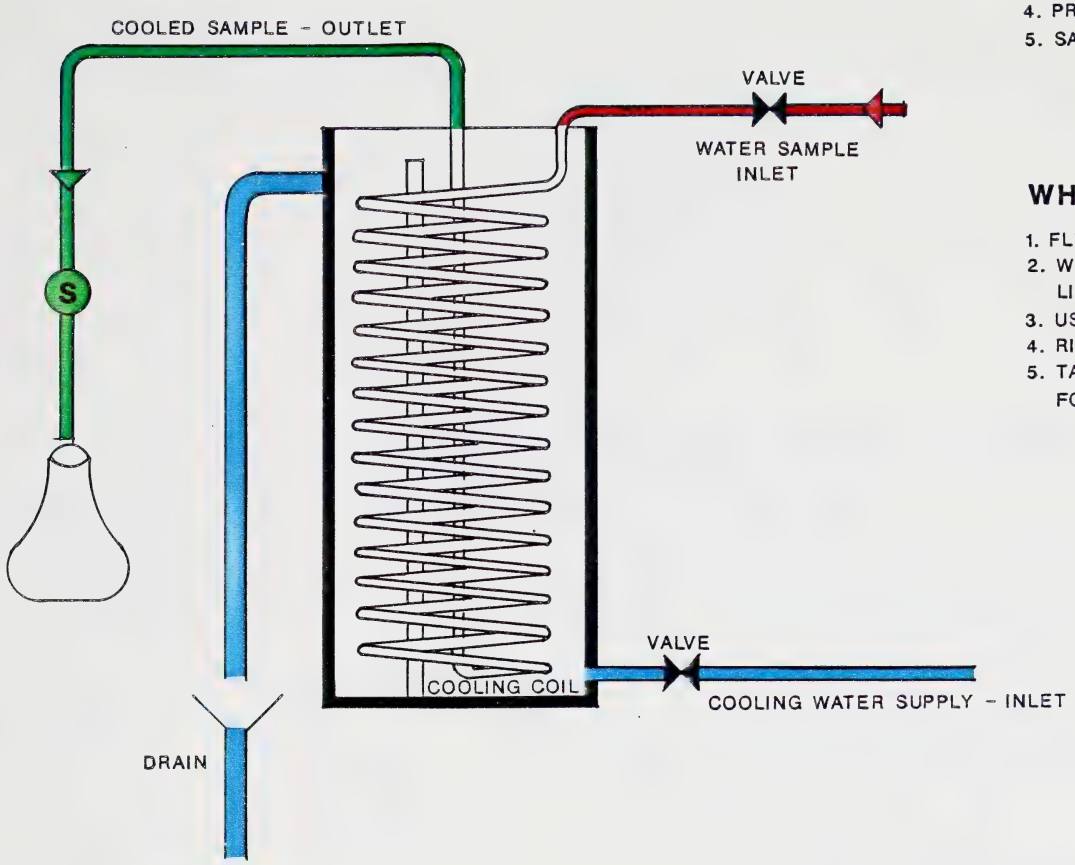
-for boiler water:
 -2-3 drops P Ind-602
 -add DSB-102 to clear
 -conductivity X 0.8
  (or TDS meter X 1)
-for other waters:
 -conductivity X 1
 (or TDS meter x 1)

Phosphate, ortho (as ppm PO4)

-5 ml filtered sample
-to 5 ml mark on mixing tube
-POS-803 to 17.5 ml mark
-1 drop POS-804
-mix & place in centre hole of comparator
-filtered sample to tubes on both sides of centre hole
-after 4 min, but less than 10 min, match colour on slide
-slide reading X 1

Figure 6

SAMPLE COOLING COIL



USE OF A COOLING COIL AT SAMPLE SITE:

1. PREVENTS FLASHING
2. PROTECTS YOU FROM BEING SCALDED
3. ELIMINATES CONCENTRATION OF SAMPLE
4. PROVIDES A MORE ACCURATE SAMPLE
5. SAVES TIME AND TROUBLE

WHEN TAKING A SAMPLE:

1. FLUSH COOLING COIL WELL BEFOREHAND
2. WHEN NO COOLING COIL, FLUSH THE LINE THOROUGHLY BEFOREHAND
3. USE A CLEAN CONTAINER
4. RINSE CONTAINER WITH SAMPLE WATER
5. TAKE MORE SAMPLE THAN NEEDED FOR ALL THE TESTS

Figure 7

WATER SYSTEMS TREATMENT - RECORD SHEET

NAME - BUILDING: _____ **LOCATION:** _____

I.D. NUMBER: **TYPE OF SYSTEM:**

TESTS	DATE: RESULTS	CHEMICAL ADDED	MAKE UP/ BLOWDOWN	DATE: RESULTS	CHEMICAL ADDED	MAKE UP/ BLOWDOWN	DATE: RESULTS	CHEMICAL ADDED	MAKE UP/ BLOWDOWN	DATE: RESULTS	CHEMICAL ADDED	MAKE UP/ BLOWDOWN
TDS												
SO_3		SULFITE			SULFITE			SULFITE			SULFITE	
PO_4		PHOSPHATE			PHOSPHATE			PHOSPHATE			PHOSPHATE	
PH (BOILER)												
"OH" ALK.		CAUSTIC			CAUSTIC			CAUSTIC			CAUSTIC	
PH (CONDENSATE)		MORPHOLINE			MORPHOLINE			MORPHOLINE			MORPHOLINE	
HARDNESS - FEED												
HARDNESS - RAW												

WATER SYSTEMS TREATMENT CONTROL RANGES

HOT WATER HEATING

PH:	8.5 - 9.5 PPM
SULFITE:	50 - 100 PPM

CHILLED WATER

PH	8.5 - 9.5
SO_3	50 -100 PPM
CATALYST -	20 ml./lb SO_3

COOLING TOWER - SEE CONSULTANT (OPEN)

STEAM BOILER

TDS	-	1500 - 3000 PPM
PO_4	-	40 - 80 PPM
SO_3	-	30 - 60 PPM
PH	-	10.5 - 11.5
PH (COND)	-	8.5 - 9.5 PPM
HARDNESS (FEED)	-	< 2.0 PPM

NOTES:

- SODIUM SULFITE INCREASES SO 3 AND TDS
- CAUSTIC INCREASES PH, "OH" ALK. AND TDS
- HEXAMETA PHOSPHATE INCREASES TDS AND PO_4 BUT DECREASES PH, AND "OH" ALK.
- TRI-SODIUM PHOSPHATE INCREASES TDS, PO_4, PH AND "OH" ALK.
- MORPHOLINE INCREASES TDS, PH, AND "OH" ALK.

COMMENTS:

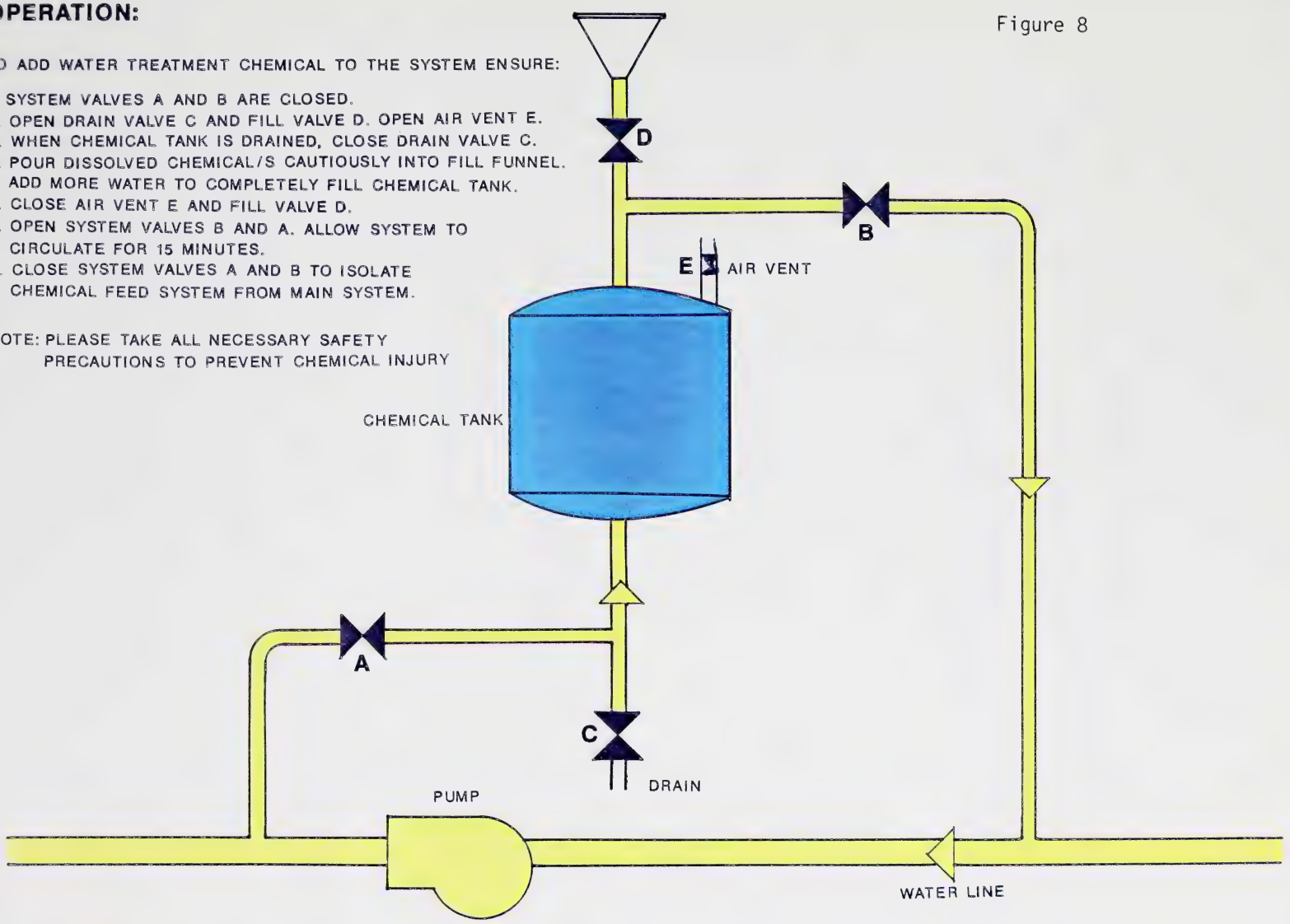
OPERATION:

Figure 8

TO ADD WATER TREATMENT CHEMICAL TO THE SYSTEM ENSURE:

1. SYSTEM VALVES A AND B ARE CLOSED.
2. OPEN DRAIN VALVE C AND FILL VALVE D. OPEN AIR VENT E.
3. WHEN CHEMICAL TANK IS DRAINED, CLOSE DRAIN VALVE C.
4. POUR DISSOLVED CHEMICAL/S CAUTIOUSLY INTO FILL FUNNEL. ADD MORE WATER TO COMPLETELY FILL CHEMICAL TANK.
5. CLOSE AIR VENT E AND FILL VALVE D.
6. OPEN SYSTEM VALVES B AND A. ALLOW SYSTEM TO CIRCULATE FOR 15 MINUTES.
7. CLOSE SYSTEM VALVES A AND B TO ISOLATE CHEMICAL FEED SYSTEM FROM MAIN SYSTEM.

NOTE: PLEASE TAKE ALL NECESSARY SAFETY PRECAUTIONS TO PREVENT CHEMICAL INJURY



POT FEEDER INSTALLED ACROSS A PUMP

FIELD TESTING SCHEDULE

SYSTEM	FREQUENCY	TESTS
1. Steam Boiler Water	1/day for power boilers 1/day for open heating boilers 1-2 days for closed heating boilers *1/week for humidifications boilers	pH, PO_4, SO_3, OH, TDS
2. Steam Boiler Feed Water	Same as above	Total Hardness
3. Condensate Water	Same as above	pH
4. Hot Water Heating & Closed Chilled Water	1/month	pH, SO_3, TDS
5. Open Cooling Tower Water & Open Chilled Water	1/week with auto blowdown 1-2 days with manual blowdown 1/year (by Sam)	PO_4(meta), TDS, pH
6. Glycol	1/year (by Sam)	% Glycol, R.A.(100%), Freeze Point, S.G., pH
7. Air Washer	1/week 1/year (by Sam)	PO_4(meta), TDS, pH Total Bacteria Count

* Provincial Museum & Archives, Edmonton - Test Daily

MONITORING SAMPING SCHEDULE - MANDATORY

SYSTEM:

Boiler Steam & Hotwater Heating	September.....March
Condensate (From Steam System)	September.....March
Chilled Water	July
Open Cooling Water	July
Feed to Cooling Tower	May
Glycol	September
Corrosion Coupons	Once per month when system is in operation
Problem Samples, Deposits, Resins	Anytime
Air Washer	December

Notes:

- A sample from each operating system of every building under the co-ordinator's jurisdiction is required.
- Adherence to timetable is important.
- Proper identification of sample is required.
- Sample bottles, mailing cartons, tags are available from the Central Laboratory.

WATER TESTING

1. Regular, accurate water testing is needed to control:

   (a) impurities
   (b) treatment levels
   (c) corrosion
   (d) deposits

   Circle correct answers.

2. Various methods of water testing include:

   (a) titration
   (b) color comparison
   (c) indicator paper test
   (d) electronic meters

   Circle correct answers.

3. Use of a cooling coil at the smapling site:

   (a) prevents flashing
   (b) protects you from being scalded
   (c) eliminates concentration of sample
   (d) provides a more accurate sample
   (e) saves time and trouble

   Circle correct answers.

4. When taking a sample:

   (a) flush cooling coil thoroughly before hand
   (b) if there is no cooling coil, flush line thoroughly before hand
   (c) use a clean container
   (d) rinse container in water being sampled
   (e) take a volume of water more than enough for all required tests

   Circle correct answers

5. When making a test be sure that:

   (a) all equipment is clean and in good order
   (b) test solutions, indicators, and reagents are fresh and at full strength
   (c) before a measuring cylinder is used, it is rinsed with the sample to be tested

   Circle correct answers

NOTES

SECTION V

SCALE CONTROL BEGINS HERE

SCALE CONTROL BEGINS HERE

Notes:

1. If you don't give the boiler water proper treatment, your boiler will suffer from carryover, sludging, scale and corrosion.

2. Long before the boiler fails, water-related problems will cause: growing safety hazard, increased maintenance cost, higher energy costs and lower boiler efficiency.

3. Scale is any hard water-formed deposit on the water side surfaces of the boiler. Most scale is a build-up of water hardners particles deposited on the boiler tube walls and other heated surfaces.

4. Sludge is the mud-like residue from the chemical treatment of hardness in the water and should be expected as the normal by-product of water treatment.

5. Scale build-up can reduce boiler water circulation, cause overheating, tube failure and waste fuel.

6. One sure way to prevent boiler scale build-up is to follow a regular schedule of water testing and treatment application.

7. In water treatment programs the term "hardness treatment" refers to any of the following: chelant, sludge conditioner, alkalinity or phosphate.

8. For scale control in boiler, water tests usually run are TDS, OH and Phosphate and these tests are all closely tied together and are all affected by blow-down, therefore before interpreting any of these tests, run all of them first.

9. There is a direct relationship between the amount of TDS in the boiler and scale control, foaming and carryover. Therefore the boiler water TDS should be kept within a practical working range.

10. High TDS in boiler water indicates not enough blowdown and on the other hand low TDS indicates too much blowdown.

11. The TDS also indicate the alkalinity and reserves of hardness treatment.

12. The major function of 'OH' alkalinity in the boiler water is to create proper conditions for scale control reactions if the 'OH' is below established control limits, the jobs of converting and precipitating the scaling impurities won't be fully accomplished.

13. Alkalinity concentrated in boiler water may come from several sources. These include: natural alkalinity of make-up water, alkalinity builder added to boiler feedwater, or alkalinity added or converted during pre-treatment.

14. Hardness in boiler water may have several sources. It may come from: contaminated condensate, make-up water or feedwater.

15. Hardness treatments prevent boiler scale by changing incoming feedwater hardness to insoluble boiler sludge or harmless neutral salts which can be removed by blowdown.

16. We test for hardness treatment reserves (phosphate) in the boiler water rather than hardness itself because there should be no hardness left in the boiler water if there is a reserve of hardness treatment. Reserves of hardness treatment in boiler water are like an insurance policy for added protection against scale.

17. There is no accurate test to measure the amount of sludge conditioner in boiler water. We may estimate the proper dosage by eyeballing the freshly drawn boiler water sample for cloudiness, to see that all particles are suspended and uniformly dispersed.

18. Proper sludge conditioning makes the sludge particles free-flowing and non-adherent so they do not contribute to scale formation.

19. Sludge conditioners are added to boiler water to disperse sludge particles so that they may be easily removed by blowdown.

20. Corrective actions should not be taken until all your water tests are run and you have interpreted your reading.

SCALE CONTROL

1. If you do not give the boiler water proper treatment, your boiler will suffer from several of the following ailments:

   (a) carryover
   (b) sludging
   (c) scale
   (d) corrosion

   Circle every answer you think is correct.

2. Scale build-up can:

   (a) reduce boiler circulation
   (b) cause overheating
   (c) cause tube failure
   (d) waste fuel

   Circle every answer you think is correct.

3. One sure way to prevent boiler scale build-up is to follow a regular schedule of water testing and treatment application.

   True or False?_____

4. (a) The material prescribed for hardness control and sludge formation in steam boilers are: phosphate and caustic.

   True or False?_____

   (b) The material prescribed for oxygen removal in boiler water is sodium sulfite.

   True or False?_____

5. (a) Proper sludge conditioning makes sludge particles free-flowing and non-adherent so they do not contribute to scale formation and can easily be removed by blowdown.

   True or False?_____

   (b) Corrective action should not be taken until all of your water tests are run and you have interpreted your readings.

   True or False?_____

NOTES

SECTION VI

CORROSION CONTROL
IN BOILER SYSTEM

CORROSION CONTROL IN BOILER OPERATION

Notes:

1. Corrosion means that the metal is eaten away.

2. Corrosion always produces some kind of residue.

3. Heat tends to speed up the corrosive effect of water on metal.

4. When water attacks iron and decomposes it, the process is known as: oxidation, corroding, or rusting.

5. Pitting and grooving attack is also called irregular grooving.

6. Acid causes grooving corrosion.
   Caustic causes gouging corrosion.
   Oxygen causes pitting corrosion.

7. The main means of corrosion control are careful regular chemical treatment, sampling, and testing.

8. It has been said that "A boiler is a thin film of magnetic iron oxide supported by steel" because the metal surface forms a self-protective coating of iron oxide which is microscopically thin. This film is extremely hard and stable and is not soluble in water.

9. There are three integral systems in the steam-water cycle - pre-boiler, boiler, and post-boiler.

10. Corrosion products from the post-boiler system may end up as deposit in the boiler.

11. Pitting can occur under deposits of corrosion products.

12. When caustic concentrates under a boiler deposit of corrosion products, you may get gouging attack.

13. Grooving occurs mainly in condensate lines.

14. Erosion corrosion such as impingement or cavitation may be caused by high velocity water or steam or shock forces of steam collapse.

15. Grooving of condensate lines is caused mainly by carbonic acid in condensate.

16. Where dissolved oxygen finds a small break in the metal's self-protective film, it causes pitting of the bare metal.

17. Carbon dioxide contained in steam causes corrosion, when dissolved in condensate. Carbon dioxide contained in steam is not corrosive while still in the form of a gas. If you have carbon dioxide in steam, it will produce carbonic acid in the condensate.

18. Corrosion products in feed water can cause tube failure, boiler deposits, further corrosion, and reduce boiler efficiency.

19. Deposits of corrosion products in boiler can cause: shutdowns, overheating, tube failure, disruption of circulation, and injuries.

20. Dissolve oxygen may enter the steam-water system through malfunctioning deaerator, make-up and vents and leaks in the condensate return system.

21. Among the best ways to keep dissolved oxygen out of boiler and condensate systems are to make sure deaerating heater is operating properly and check vacuum return system for suction leaks.

22. Carbon dioxide gets into the boiler and steam system by way of feed-water, certain internal treatments and make-up water.

23. Neutralizing and filming amines are called chemical inhibitors.

24. Control of caustic gouging involves sludge conditioning, blow down, eliminating excessive alkalinity in boiler water and controlling return of corrosion products to the boiler.

25. The following conditions that could indicate possible corrosion in boiler and condensate systems are: low PH in condensate, unexplained increase in sulphite use, leaks in condensate systems, the presence of dissolve iron in condensate corrosion of installed test specimens or coupons and rust in sight glasses.

CORROSION

1. Corrosion means that metal is:

   (i) Inhibited
   (ii) eaten away
   (iii) accumulated

2. Deposits of corrosion products in boilers can cause:

   (a) shutdowns
   (b) overheating
   (c) excessive sulfite residuals
   (d) tube failures
   (e) injuries
   (f) boiler carryover
   (g) poor circulation

   Circle 5 correct answers.

3. Dissolved onygen may enter the steam-water system through:

   (a) malfunctioning deaerator
   (b) air preheater
   (c) make-up water
   (d) excessive combustion air
   (e) vents and leaks in condensate return systems

   Circle 3 correct answers.

4. Carbon dioxide gets into the boiler and steam system by way of:

   (a) feedwater
   (b) certain internal treatment
   (c) combustion gases
   (d) make-up water

   Circle 3 correct answers.

5. Circle six of the following conditions that could indicate possible corrosion in the boiler and condensate systems:

   (a) low PH in condensate
   (b) unexplained increase in sulphite use
   (c) boiler foaming
   (d) leaks in condensate system
   (e) presence of dissolved iron in condensate
   (f) abnormal increase in steam generation
   (g) corrosion of installed test coupons
   (h) increased recovery of condensate
   (i) rust in sight glass

NOTES

SECTION VII

GLOSSARY OF WATER CHEMISTRY TERMS

A GLOSSARY OF WATER CHEMISTRY TERMS

Acid - An acid is a substance that furnishes hydrogen ions in an aqueous solution. It reacts with a pH indicator to give a reading below pH7.0.

Alkali - A chemical compound that furnishes hydroxide ions in an aqueous solution. It reacts with a pH indicator to give a reading above pH7.0.

Analysis - The examination of a water sample to determine its chemical composition and characteristics.

Boiler Water Sample - A representative sample of the circulating boiler water.

Buffer - A substance which tends to resist changes in the pH of a solution.

Burette - A long narrow titrating column that has been accurately calibrated to indicate the exact volume of liquid dispensed in the test procedure.

Catalyst - A substance which alters the rate of reaction, but which itself remains unchanged chemically.

Caustic - This refers to caustic soda which is sodium hydroxide.

Coagulate - Congeal or form a jelly-like mass.

Colorimetric - A name given to a chemical test method where the result of the test is determined by the amount or shade of color developed.

Color Standard - A hermitically sealed glass tube containing a stable solution equivalent in colour to the colour developed when an indicator is added to a definite concentration of a chemical.

Comparator - The device for holding colour standards and a test sample in adjacent positions so that the colours of each may be easily compared, one with the other.

Concentration - Amount of a substance per unit volume.

Corrosion - A process of deterioration where metal parts are slowly eaten away.

Dissolved Oxygen - The amount of oxygen dissolved in a water.

Endpoint - The point in a titration procedure where a colour change in the sample takes place.

Filtration - The separating of a liquid from suspended matter in it by passing the liquid through a filter paper.

Hard Water - Water that has a high calcium or magnesium content.

Hardness, Total - The sum of the calcium hardness plus the magnesium hardness.

Indicator - A chemical reagent added to a test sample to bring about a colour reaction.

Inhibitor - A chemical that interferes with a chemical reaction to reduce or eliminate corrosion.

Meniscus - The curved surface of a liquid within a container.

Magnesium Hardness - The amount of magnesium which is present in the sample.

ML (Millilitre) - One-thousandth part of a litre.

Neutral - A water sample is neutral if it has a pH reading of 7.00.

Parts Per Million (ppm) - A unit of measurement used in chemical testing which indicates the parts by weight in relation to one million parts of water.

pH - This is a scale base on the hydrogen ion concentration by which water and other substances are measured to determine if they are acid, neutral or alkaline.

pH Scale - Numerical scale used to measure the strength of acids and bases.

Pipette - A "dropper" device that is usually calibrated for measuring small amounts of liquid.

Precipitate - An insoluble compound formed by chemical action between two or more soluble compounds in solution.

Precipitation - The settling of insoluble compounds formed in solution.

Reagent - A chemical material in liquid, powder or tablet form that has been especially prepared for use in chemical testing.

Residual - The amount or level of an unreacted material present in the water.

Scale - A hard, crusty deposit which may be found inside boilers, tubes, pipes, valves, etc.

Scale Forming - Water which contains the chemical compounds capable of leaving scale deposits.

Shelf Life - The length of time that an analytical reagent can be stored without its chemical composition deteriorating or its undergoing some change that will make the reagent unacceptable for use.

Soft Water - Water that has a very low calcium and magnesium content.

Soluble - A substance which is easily liquified or dissolved.

Standard Solution - A solution with a precise known composition.

Test Tube — A glass or plastic tube in which a sample water is treated for testing purposes, also called a comparator tube, sample tube, test cell.

T.D.S. — Total dissolved solids.

Titration — A chemical test method using a reagent that is chemically keyed to the unknown factor being tested. Usually an indicator is added to the test sample and then the titrating solution is added in measured amounts. When sufficient titrating solution is added to bring about a colour change in the sample (the end-point) the amount of solution added is noted and its volume multiplied by a standard factor gives the result in ppm of the chemical compound being measured.

Turbidity — A suspension of fine particles that obscures light rays but requires many days for settling out because of the small particle size.

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